

Eric Vaandering

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Academic/Scientific Appointments

2003–	Research Assistant Professor	Vanderbilt University, Nashville, TN
2000–2003	Research Associate	Vanderbilt University, Nashville, TN
2000	Research Associate	University of Colorado, Boulder, CO
1994–2000	Research Assistant	University of Colorado, Boulder, CO
1993–1994	Teaching Assistant	University of Colorado, Boulder, CO

Education

1989–1993	B. S. with Honors	Physics	Valparaiso University
1993–1995	M. S.	Physics	University of Colorado
1993–2000	Ph. D.	Physics	University of Colorado
2000	Post Doctoral	Elementary Particle Physics	University of Colorado
2000–	Post Doctoral	Elementary Particle Physics	Vanderbilt University

Advisors

Graduate:	John Cumalat (University of Colorado)
Postdoctoral:	Paul Sheldon (Vanderbilt University)

Research Interests & Experience

My primary research interest has been the study of heavy quark decays. These decays provide information about the fundamental particles and forces of nature, particularly the strong and weak forces. While there are a wealth of measurements to be made within the context of the Standard Model, even more exiting is physics beyond the Standard Model and it's effects in the c and b sectors. For instance, CP violating processes beyond the Standard Model are a likely explanation for the matter asymmetry of the universe and may have effects in the B sector to which precision experiments are sensitive.

In pursuing this interest in heavy quark physics, I have been an active and important member of the E-687, FOCUS, and BTeV collaborations at Fermilab. My contributions to these experiments and collaborations are detailed below. I have recently applied for membership in the CMS collaboration working at the LHC.

2000–present, Research Associate & Research Assistant Professor, Vanderbilt University. As a post-doc and Research Assistant Professor at Vanderbilt University, I have split my time between the FOCUS, BTeV, and recently CMS experiments. My early work at Vanderbilt was a continuation of my thesis work on FOCUS, resulting in measurements of the widths of Σ_c baryons. This work was published in *Physics Letters B* in 2002.

My current research interest has been working with the Genetic Programming (GP) technique to extract signals from the FOCUS data. The goal of this project is to set limits (or observe

signals) on the doubly Cabibbo suppressed decays $D_s^+ \rightarrow K^+ K^+ \pi^-$ and $\Lambda_c^+ \rightarrow p K^+ \pi^-$. An article [3] detailing this method and using the doubly Cabibbo suppressed decay $D^+ \rightarrow K^+ \pi^+ \pi^-$ as an example has been submitted for publication in *Nuclear Instruments and Methods*. Using this technique, I typically obtain factor of two improvements in signal yield or sensitivity at the same purity compared to more standard analysis techniques. To my knowledge, this is the first application of GP to high energy physics data. In March, 2004, I was invited to give a series of graduate lectures on this topic at Pavia University, a FOCUS and BTeV collaborating institution.

From 2002–2004, I supervised a Vanderbilt undergraduate in the analysis and subsequent publication (*Physics Letters B*) of six-body decays of the D^0 . I have also contributed to FOCUS by organizing and running a large $c\bar{c}$ Monte Carlo generation and distribution program for FOCUS collaborators and I have been active on several publication review committees and served as the chair of our charmed baryon asymmetry and $D^0 \rightarrow K^+ K^- \pi^+ \pi^-$ paper review committees.

As a member of BTeV, my responsibilities included work on the design and construction of the muon detector system and implementation of an inventory and quality assurance tracking database for the muon system production. As part of this project, I designed the software and worked on the hardware to measure the tension and current draw of the 32,000+ proportional tubes in the proposed BTeV muon detector.

Additionally, I designed, developed, and continue to maintain and enhance DocDB, the system used for cataloging all documentation produced by the BTeV collaboration. This software had a major impact on the way BTeV collaborated and has since been adopted by other experiments, including the CMS Pixel project, and the Fermilab Beams and Computing divisions.

From 2001–2002 I was involved with the BTeV-RTES project, which seeks to develop fault tolerant and fault management technologies for HEP trigger and DAQ hardware.

1994–2000: Research Assistant & Research Associate, University of Colorado. As a member of the FOCUS collaboration, I performed three major tasks:

Physics Analysis: My Ph. D. thesis (completed in January 2000) presents $\Sigma_c - \Lambda_c^+$ mass difference measurements for Σ_c^0 , Σ_c^+ , and Σ_c^{++} and width measurements of Σ_c^0 and Σ_c^{++} . Also included are confirming observations of the decays $\Sigma_c^* \rightarrow \Lambda_c^+ \pi^\pm$. As a post-doc, I continued my Ph. D. work on Σ_c mass splittings which was published in *Physics Letters B* in early 2000.

Hardware experience: I was the principal person responsible for the construction, calibration, data acquisition, and maintenance of the FOCUS inner electromagnetic calorimeter, a lead glass device with 802 channels. I also designed and implemented a trigger for $J/\psi \rightarrow e^+ e^-$ events.

Computer experience: I was one of two coordinators of the FOCUS reconstruction effort using the Fermilab computing farms and a designer of the reconstruction software. In total, this was a two year effort in which I worked with parallel processing, algorithm optimization, and web-based interactive programs to accomplish our goal of reconstructing a 25 Terabyte data sample in less than 10 months.

1991–1993: Research Assistant, High Energy Physics Division, Argonne National Laboratory. As an undergraduate, I performed a Monte Carlo feasibility study of a method for producing a polarized anti-proton beamline at medium energies. This was done in conjunction with an Honors Project at Valparaiso University.)

Conference Talks, Colloquia, Seminars

Invited Talks:

1. “Hadronic Charm Decays at FOCUS” for *Workshop on Heavy Quarks at Fixed Target*, Fermi National Accelerator Laboratory, 10–12 October 1998.
2. “Recent Fixed Target Results” for *Fermilab Users’ Meeting, 2001*, Fermi National Accelerator Laboratory, 11–12 June 2001.
3. “FOCUS Spectroscopy and Lifetimes” for *HADRON 2001, IXth International Conference on Hadron Spectroscopy*, IHEP, Protvino, Russia, 25 August – 1 September 2001.
4. “BTeV Physics Reach” for *Fermilab Users’ Meeting, 2003*, Fermi National Accelerator Laboratory, 2–3 June 2003.
5. “Charmed Hadron Spectroscopy from FOCUS” for *XXXIXth Rencontres de Moriond: QCD and High Energy Hadronic Interactions*, La Thuile, Italy, 28 March – 4 April 2004.

Contributed Talks:

1. “Preliminary Measurements of the Σ_c^0 and Σ_c^{++} Mass Splittings from FOCUS” for *American Physical Society Centennial Meeting*, Atlanta, 20–26 March 1999.
2. “Charmed Baryon Results from FOCUS” for *7th Conference on the Intersection of Particle and Nuclear Physics*, Quebec City, 22–28 May 2000.
3. “FOCUS Lifetime Measurements” for *5th International Conference on Hyperons, Charm and Beauty Hadrons (BEACH 2002)*, Vancouver, 24–29 June 2002.
4. “A Web Based Document Database” for *2003 Conference for Computing in High Energy and Nuclear Physics (CHEP03)*, San Diego, 24–28 March 2003.
5. “The BTeV Detector” for *2003 International Europhysics Conference on High Energy Physics*, Aachen, Germany, 17–23 July 2003.
6. “Genetic Programming and Its Application to HEP” for *Computing in High Energy and Nuclear Physics 2004 (CHEP04)*, Interlaken, Switzerland, 27 September – 1 October 2004.

Colloquia and Seminars:

1. “Charm Physics and FOCUS” for *Valparaiso University Physics Colloquium*, Valparaiso, IN, 4 April 1997.
2. “ Σ_c Mass Differences and Other Results from FOCUS” for *Laboratory of Nuclear Studies Journal Club*, Cornell University, Ithaca, NY, 27 January 2000

3. “ Σ_c Mass Differences and Widths from FOCUS” for *Fermi National Accelerator Laboratory*, Batavia, IL, 3 May 2000
4. “Charmed Baryons and Other Results from FOCUS” for *Laboratory of Nuclear Studies Journal Club*, Cornell University, Ithaca, NY, 18 May 2000
5. Lecture Series: “Genetic Algorithms and Genetic Programming” for Pavia University, 16–30 March 2004
6. “Genetic Programming and HEP” for *INFN – LNF Colloquium*, INFN – Laboratori Nazionali di Frascati, Frascati, Italy, 18 March 2004
7. “Genetic Programming and HEP” for *Nuclear and Particle Physics Seminar*, Vanderbilt University, Nashville, TN, 1 November 2004
8. “Genetic Programming and Its Application to HEP” for *Computing Techniques Seminar*, Fermi National Accelerator Laboratory, 18 November 2004

Publications

- [1] J. M. Link et al. Measurements of the Σ_c^0 and Σ_c^{++} mass splittings. *Phys. Lett.*, B488:218–224, 2000.
- [2] J. M. Link et al. Measurement of natural widths of Σ_c^0 and Σ_c^{++} baryons. *Phys. Lett.*, B525:205–210, 2002.
- [3] J. M. Link et al. Application of genetic programming to high energy physics event selection. 2005. hep-ex/0503007, to be published in Nucl. Instrum. Meth.
- [4] J. M. Link et al. Search for $\Lambda_c^+ \rightarrow pK^+\pi^-$ and $D_s^+ \rightarrow K^+K^+\pi^-$ using genetic programming event selection. *Phys. Lett.*, B624:166–172, 2005.
- [5] J. M. Link et al. A measurement of lifetime differences in the neutral D meson system. *Phys. Lett.*, B485:62–70, 2000.
- [6] J. M. Link et al. Search for CP violation in D^0 and D^+ decays. *Phys. Lett.*, B491:232–239, 2000.
- [7] J. M. Link et al. A study of the decay $D^0 \rightarrow K^+\pi^-$. *Phys. Rev. Lett.*, 86:2955–2958, 2001.
- [8] J. M. Link et al. A measurement of branching ratios of D^+ and D_s^+ hadronic decays to four-body final states containing a K_S^0 . *Phys. Rev. Lett.*, 87:162001, 2001.
- [9] J. M. Link et al. Measurement of the relative branching ratio $\text{BR}(\Xi_c^+ \rightarrow pK^-\pi^+)/\text{BR}(\Xi_c^+ \rightarrow \Xi^-\pi^+\pi^+)$. *Phys. Lett.*, B512:277–282, 2001.
- [10] J. M. Link et al. Search for CP violation in the decays $D^+ \rightarrow K_S^0\pi^+$ and $D^+ \rightarrow K_S^0K^+$. *Phys. Rev. Lett.*, 88:041602, 2002.
- [11] J. M. Link et al. A new measurement of the Ξ_c^+ lifetime. *Phys. Lett.*, B523:53–59, 2001.

- [12] J. M. Link et al. A high statistics measurement of the Λ_c^+ lifetime. *Phys. Rev. Lett.*, 88:161801, 2002.
- [13] J. M. Link et al. Evidence for new interference phenomena in the decay $D^+ \rightarrow K^- \pi^+ \mu^+ \nu$. *Phys. Lett.*, B535:43–51, 2002.
- [14] J. M. Link et al. New measurement of the D^0 and D^+ lifetimes. *Phys. Lett.*, B537:192–200, 2002.
- [15] J. M. Link et al. Measurements of relative branching ratios of Λ_c^+ decays into states containing Σ . *Phys. Lett.*, B540:25–32, 2002.
- [16] J. M. Link et al. A new measurement of the Ξ_c^0 lifetime. *Phys. Lett.*, B541:211–218, 2002.
- [17] J. M. Link et al. Measurement of the D^+ and D_s^+ decays into $K^+ K^- K^+$. *Phys. Lett.*, B541:227–233, 2002.
- [18] J. M. Link et al. New measurements of the $\Gamma(D^+ \rightarrow \bar{K}^{*0} \mu^+ \nu)/\Gamma(D^+ \rightarrow K^- \pi^+ \pi^+)$ and $\Gamma(D_s^+ \rightarrow \phi \mu^+ \nu)/\Gamma(D_s^+ \rightarrow \phi \pi^+)$ branching ratios. *Phys. Lett.*, B541:243–250, 2002.
- [19] J. M. Link et al. New measurements of the $D^+ \rightarrow \bar{K}^{*0} \mu^+ \nu$ form factor ratios. *Phys. Lett.*, B544:89–96, 2002.
- [20] J. M. Link et al. Observation of a 1750 MeV/ c^2 enhancement in the diffractive photoproduction of $K^+ K^-$. *Phys. Lett.*, B545:50–56, 2002.
- [21] J. M. Link et al. Study of the Cabibbo-suppressed decay modes $D^0 \rightarrow \pi^- \pi^+$ and $D^0 \rightarrow K^- K^+$. *Phys. Lett.*, B555:167–173, 2003.
- [22] J. M. Link et al. Charm system tests of CPT and Lorentz invariance with FOCUS. *Phys. Lett.*, B556:7–13, 2003.
- [23] J. M. Link et al. Measurement of the Ω_c^0 lifetime. *Phys. Lett.*, B561:41–48, 2003.
- [24] J. M. Link et al. Study of hadronic five-body decays of charmed mesons. *Phys. Lett.*, B561:225–232, 2003.
- [25] J. M. Link et al. Studies of correlations between D and \bar{D} mesons in high energy photoproduction. *Phys. Lett.*, B566:51–60, 2003.
- [26] J. M. Link et al. Measurements of Ξ_c^+ branching ratios. *Phys. Lett.*, B571:139–147, 2003.
- [27] J. M. Link et al. Search for rare and forbidden 3-body di-muon decays of the charmed mesons D^+ and D_s^+ . *Phys. Lett.*, B572:21–31, 2003.
- [28] J. M. Link et al. Study of the decay mode $D^0 \rightarrow K^- K^- K^+ \pi^+$. *Phys. Lett.*, B575:190–197, 2003.
- [29] J. M. Link et al. Charm-anticharm baryon production asymmetries in photon-nucleon interactions. *Phys. Lett.*, B581:39–48, 2004.
- [30] J. M. Link et al. Dalitz plot analysis of D_s^+ and D^+ decay to $\pi^+ \pi^- \pi^+$ using the K-matrix formalism. *Phys. Lett.*, B585:200–212, 2004.

- [31] J. M. Link et al. Measurement of masses and widths of excited charm mesons D_2^* and evidence for broad states. *Phys. Lett.*, B586:11–20, 2004.
- [32] J. M. Link et al. Measurements of six-body hadronic decays of the D^0 charmed meson. *Phys. Lett.*, B586:21–26, 2004.
- [33] J. M. Link et al. New measurements of the $D_s^+ \rightarrow \phi \mu^+ \nu$ form factor ratios. *Phys. Lett.*, B586:183–190, 2004.
- [34] J. M. Link et al. Study of hadronic five-body decays of charmed mesons involving K_S^0 . *Phys. Lett.*, B586:191–197, 2004.
- [35] J. M. Link et al. Measurement of the ratio of the vector to pseudoscalar charm semileptonic decay rate $\Gamma(D^+ \rightarrow K^{*0} \mu^+ \nu_\mu) / \Gamma(D^+ \rightarrow K^0 \mu^+ \nu_\mu)$. *Phys. Lett.*, B598:33–41, 2004.
- [36] J. M. Link et al. Study of the doubly and singly Cabibbo suppressed decays $D^+ \rightarrow K^+ \pi^+ \pi^-$ and $D_s^+ \rightarrow K^+ \pi^+ \pi^-$. *Phys. Lett.*, B601:10–19, 2004.
- [37] J. M. Link et al. Measurement of the branching ratio of the decay $D^0 \rightarrow \pi^- \mu^+ \nu$ relative to $D^0 \rightarrow K^- \mu^+ \nu$. *Phys. Lett.*, B607:51–58, 2005.
- [38] J. M. Link et al. A study of $D^0 \rightarrow K_S^0 K_S^0 X$ decay channels. *Phys. Lett.*, B607:59–66, 2005.
- [39] J. M. Link et al. Analysis of the semileptonic decay $D^0 \rightarrow \bar{K}^0 \pi^- \mu^+ \nu$. *Phys. Lett.*, B607:67–77, 2005.
- [40] J. M. Link et al. Measurements of the q^2 dependence of the $D^0 \rightarrow K^- \mu^+ \nu$ and $D^0 \rightarrow \pi^- \mu^+ \nu$ form factors. *Phys. Lett.*, B607:233–242, 2005.
- [41] J. M. Link et al. Study of the decay mode $D^0 \rightarrow K^- K^+ \pi^- \pi^+$. *Phys. Lett.*, B610:225–234, 2005.
- [42] J. M. Link et al. Measurement of the doubly Cabibbo suppressed decay $D^0 \rightarrow K^+ \pi^-$ and a search for charm mixing. *Phys. Lett.*, B618:23–33, 2005.
- [43] J. M. Link et al. Hadronic mass spectrum analysis of $D^+ \rightarrow K^- \pi^+ \mu^+ \nu$ decay and measurement of the $K^*(892)^0$ mass and width. *Phys. Lett.*, B621:72–80, 2005.
- [44] J. M. Link et al. A measurement of the D_s^+ lifetime. *Phys. Rev. Lett.*, 95:052003, 2005.
- [45] J. M. Link et al. Search for a strongly decaying neutral charmed pentaquark. *Phys. Lett.*, B622:229–238, 2005.
- [46] J. M. Link et al. Search for T violation in charm meson decays. *Phys. Lett.*, B622:239–248, 2005.
- [47] J. M. Link et al. Study of Λ_c^+ Cabibbo favored decays containing a Λ baryon in the final state. *Phys. Lett.*, B624:22–30, 2005.
- [48] J. M. Link et al. Reconstruction of vees, kinks, Ξ^- ’s, and Ω^- ’s in the FOCUS spectrometer. *Nucl. Instrum. Meth.*, A484:174–193, 2002.
- [49] J. M. Link et al. Čerenkov particle identification in FOCUS. *Nucl. Instrum. Meth.*, A484:270–286, 2002.

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- [56] P. L. Frabetti et al. On the narrow dip structure at 1.9 GeV/ c^2 in diffractive photoproduction. *Phys. Lett.*, B578:290–296, 2004.
- [57] E. W. Vaandering, H. M. Spinka, and J. S. Hofmann. A possible method to produce a polarized anti-proton beam at intermediate-energies. *Nucl. Instrum. Methods*, A351:266, 1994.

Selected Conference Proceedings

- [1] E. W. Vaandering. Dalitz analysis, rare decays, and charmed baryons at FOCUS and E687. In Harry W. K. Cheung and Joel N. Butler, editors, *Heavy Quarks at Fixed Target*, pages 270–279. American Institute of Physics, 1998.
- [2] E. W. Vaandering. Recent charmed baryons results from FOCUS. In Zohreh Parsa and William J. Marciano, editors, *The 7th Conference on the Intersections of Particle and Nuclear Physics*, pages 583–587. American Institute of Physics, 2000.
- [3] E. W. Vaandering. Recent lifetime results from FOCUS. *Nucl. Phys. Proc. Suppl.*, 115B:136–140, 2003. Proceedings of the 5th International Conference on Hyperons, Charm and Beauty Hadrons, edited by C.S. Kalman *et al.*
- [4] E. W. Vaandering. A web based document database. *ECONF*, C0303241:MONT007, 2003. Contributed to *2003 Computing in High Energy and Nuclear Physics (CHEP03)*, hep-ex/0305086, <http://www.slac.stanford.edu/econf/C0303241/proc/papers/MONT007.PDF>.
- [5] E. W. Vaandering. The BTeV experiment. *Eur. Phys. J.*, C33:S987–S989, 2004. Contributed to *International Europhysics Conference on High Energy Physics (EPS)*, hep-ex/0310056.
- [6] E. W. Vaandering. Charmed hadron spectroscopy from FOCUS. 2004. Contributed to *XXXIXth Rencontres de Moriond: QCD and High Energy Hadronic Interactions*, hep-ex/0406044.
- [7] H. Spinka, E. W. Vaandering, and J. S. Hofmann. A possible method to produce a polarized anti-proton beam at intermediate-energies. Contributed to 11th International Symposium on High Energy Spin Physics and the 8th International Symposium on Polarization Phenomena in Nuclear Physics (SPIN 94), Bloomington, IN, 15–22 Sep 1994.